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Report on Data Assimilation Experiments Using the RTOVS Retrievals

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13. Abstract (Maximum 200 words). NOGAPS's short to medium range weather forecasts, which started from analysis assimilating NESDIS's new satellite temperature retrievals, demonstrate less forecast skill than forecasts using the old temperature retrievals. Several data assimilation tests are discussed in which different retrieved satellite temperature errors are set and restrictions of the satellite temperature data are set in the Northern Hemisphere. The recommendation of this report is that with the current NOGAPS data assimilation/forecast system NESDIS RTOVS temperature retrievals not be used in the Northern Hemisphere.				
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1. Introduction

The current Navy Operational Global Atmospheric Prediction System's (NOGAPS) multivariate optimum interpolation (MVOI) assimilates National Environmental Satellite, Data, and Information Service's (NESDIS) satellite retrievals of temperature. Any data assimilation system is highly dependent on the assumptions of the forecast and observational errors. Over the many years that NOGAPS has been operational at Fleet Numerical Meteorology and Oceanography Center (FNMOC), the errors have been carefully adjusted to correspond to the model first guess (NOGAPS's 6-hour forecast) and the characteristics of the observational data. The satellite temperature soundings are provided from NESDIS, which uses statistical algorithms to derive a temperature product from the satellite radiances. These include both the TIROS Operational Vertical Sounder (TOVS) and the Defense Meteorology Satellite Program (DMSP) satellites.

2. NOGAPS Forecast Comparisons Using TOVS And RTOVS

NESDIS has developed a new revised algorithm for the satellite temperature profiles, called RTOVS (Revised TOVS) and plans to shortly switch off the old algorithm. Unfortunately, the use of the new temperature retrievals in NOGAPS has a negative impact on the predictive skill of the system. Figure 1 is a comparison of the average Northern Hemisphere's 500 mb height anomaly correlation (the standard measure of global numerical weather forecast model skill) for the month of November 1997 using the current retrieval algorithm, which we call TOVS, and the new RTOVS retrievals in the T79L18 version of NOGAPS. A perfect skill score corresponds to anomaly correlation of 1.0, therefore the higher the curve the better the skill. As can be seen there is less predictive skill of NOGAPS in the Northern Hemisphere (about 4 hours at 120 hours) using the RTOVS retrievals in comparison to using the TOVS retrievals. All the Northern Hemisphere's areas displayed some loss of skill at 120 hours, with the most dramatic loss occurring over the oceans. Figures 2 and 3 are comparisons of the average 500-mb height anomaly correlation over the Atlantic Ocean and Eastern Pacific Ocean. Using RTOVS, NOGAPS's skill in the Atlantic is over 18 hours less than the skill using TOVS, while in the Eastern Pacific the use of RTOVS has reduced the skill by approximately 12 hours for the 120-hour forecast.

Figures 1-3 show the ability of NOGAPS to predict anomalies from the mean climate patterns. Figures 4-6 are the corresponding graphs for the 500-mb height root mean square errors (forecast minus analysis), which indicates the actual magnitude of the error. Overall, there is an increase in the height error over the entire Northern Hemisphere (Figure 4), with the maximum increase in forecast error using the new retrievals occurring over the Atlantic (Figure 5) and the Eastern Pacific (Figure 6).

Figures 1-6 are based on comparisons of the forecast fields with the initial fields, which are determined by the MVOI as a weighted combination of the first guess and the observational data. Figure 7 is a graph of the 500-mb forecast root mean square error heights with only observational data, in this case radiosondes over North America. As with the field to field comparison, there is a demonstrated loss of predictive skill in the current NOGAPS using the RTOVS retrievals in place of the TOVS retrievals.

3. Data Assimilation Tests Using RTOVS

Many (but in no way exhaustive) tests were conducted using various different assignments of satellite retrieval error for the RTOVS retrievals. Figure 8 is a plot of the average Northern Hemisphere's 500-mb height anomaly correlation for several different data assimilation runs. The results are labeled TOVS, RTOVS, RTOVSX, RTOVS2, and RTOVS8. All tests were conducted at T79L18 and used the identical version of the forecast model. In addition, all tests used the same criterion for gross satellite data rejection. The test TOVS uses the old NESDIS satellite retrievals and RTOVS uses the new NESDIS algorithm, and these results are the same as shown in Figure 1. RTOVS8 uses the new RTOVS retrievals, but increases the satellite errors by a factor of 8 over the current operational errors for TOVS. RTOVS2 uses the RTOVS data, but increases the satellite error by a factor of 2 and removes the satellite data over Eastern Asian high terrain (30N-70N, 90E-120E). Of all the tests conducted, RTOVS2 represents NOGAPS's best-forecast results with the RTOVS data in the Northern Hemisphere without actually removing all the satellite temperature retrieval data in the Northern Hemisphere. RTOVSX uses the new retrievals RTOVS, but removes all satellite retrievals from 20N to 60N. The best results were with RTOVSX and TOVS. RTOVS2 was slightly less skillful than these 2 tests. Both RTOVS and RTOVS8 displayed considerably less forecast skill. Other tests (not shown) included increasing the satellite error by a factor of 4, removing the data over land areas,

removing the DMSP satellite data, and removing all satellite data over the Pacific. All these results were comparable to the results of shown by RTOVS and RTOVS8 in Figure 8.

Figures 9 and 10 are comparisons of the RTOVS and RTOVSX tests. Figure 9 includes 500-mb height anomaly correlations results for various sub areas in the Northern Hemisphere and Figure 10 includes 500-mb height root mean errors using radiosondes for different land regions. As can be seen the RTOVSX test is clearly superior, both in terms of comparisons with climate anomalies and in terms of comparisons with observational data over all Northern Hemispheric areas.

A final question is what impact can be expected if some of the satellite data is restricted in the Northern Hemisphere. Figure 11 contains 2 Northern Hemispheric 500-mb charts. The top corresponds to the operational (T159L18, which uses TOVS) 120 hour forecast starting at 1997112300 and verifying at 1997112800, and the bottom is a plot of the T79L18 RTOVSX 120 hour forecast for the same period. This time was chosen for its large predicted trough in the Pacific, which was correctly forecast. The operational 120 hour, 500-mb anomaly correlation for the Eastern Pacific was 0.93. While there are some minor differences, which can be attributed to the difference in horizontal resolution, the operational and the data restricted forecasts are very similar. Both show the presence of a deep trough over the Pacific. As with the operational forecast, RTOVSX has a high 120-hour, 500-mb anomaly correlation for the Eastern Pacific (0.90). This matching of operational with RTOVSX results occurred throughout the month of November 1997 (i.e. when the operational model did well, RTOVSX did well and when operational model did poorly, RTOVSX tended to also show poor forecast results).

4. Conclusion

In conclusion, the use of the new RTOVS in the current NOGAPS will lead to loss of medium range skill (this has been verified in real time with comparisons of the control and beta T79L18). Until the implementation of more advanced data assimilation techniques, such as the direct assimilation of radiances that is under development, it is recommended that a modified data assimilation strategy be employed to restrict the use of NESDIS RTOVS retrievals in the Northern Hemisphere.

T79L18 DATA ASSIMILATION TEST
500 MB NORTH HEM HEIGHT ANOMALY COR
1997110112 - 1997113012

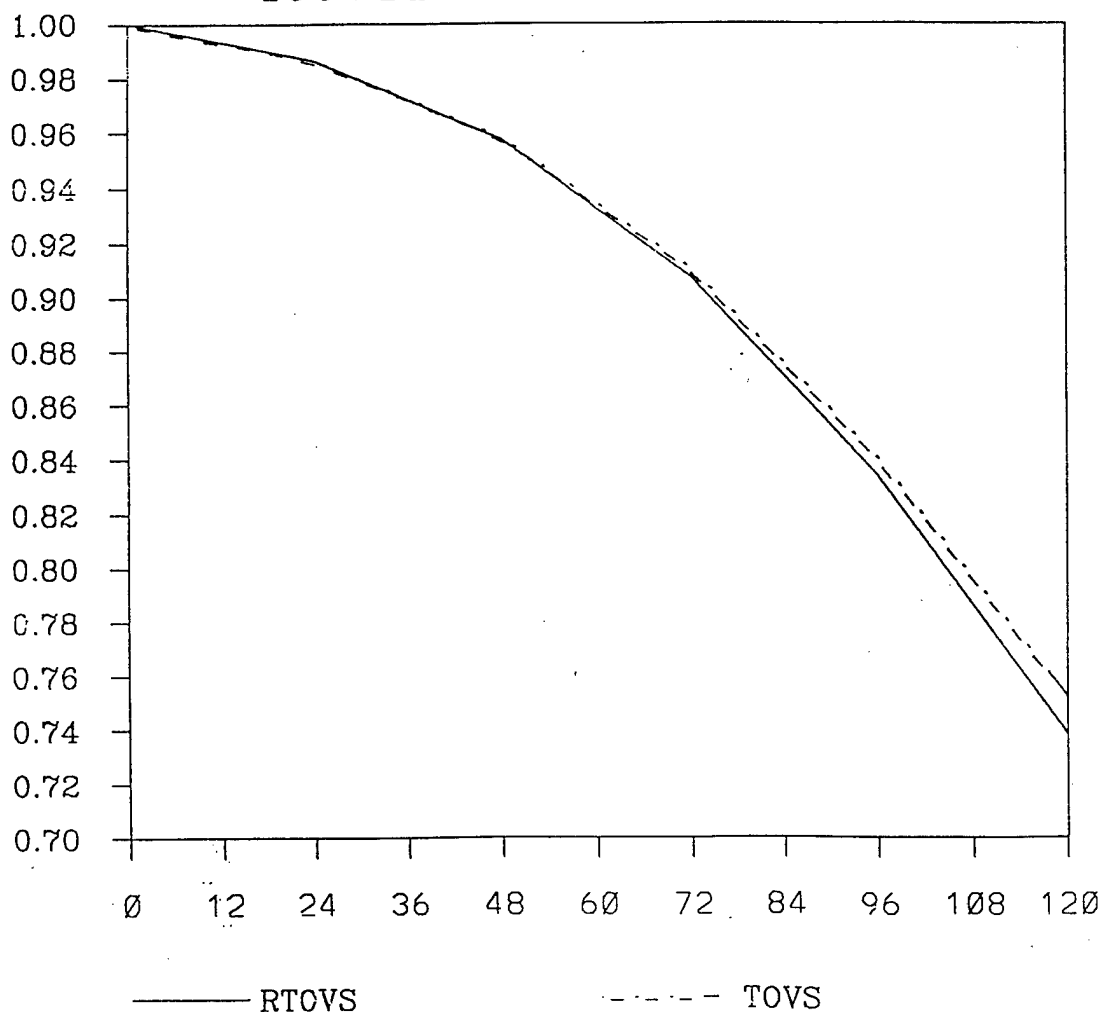


Figure 1: A comparison of the average Northern Hemisphere's 500 mb height anomaly correlation for the month of November 1997 using the retrievals from the older TOVS algorithm and from the new RTOVS algorithm in the T79L18 version of NOGAPS. The x axis is forecast hours (0-120 hours) and the y axis is anomaly correlation, which has a range of 1.0 for a perfect forecast to -1.0 for negatively correlated forecast. An anomaly correlation of 0.6 is considered the limit of useful forecast skill.

T79L18 DATA ASSIMILATION TEST
500 MB ATLANTIC HEIGHT ANOMALY COR
1997110112 - 1997113012

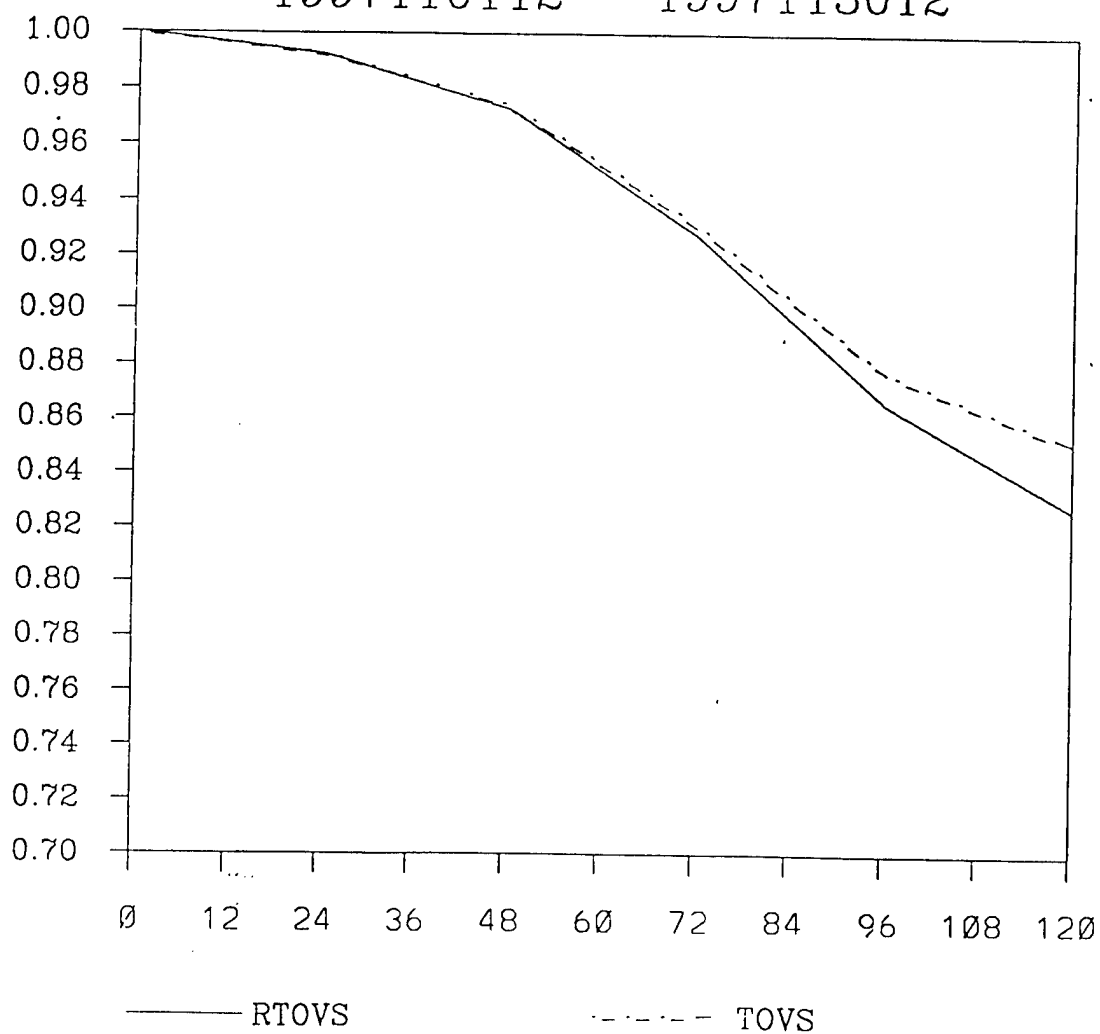


Figure 2: A comparison of the average 500 mb height anomaly correlation using the retrievals from the older TOVS algorithm and from the new RTOVS algorithm in the T79L18 version of NOGAPS over the Atlantic Ocean for the month of November 1997.

T79L18 DATA ASSIMILATION TEST
 500 MB EAST PAC HEIGHT ANOMALY COR
 1997110112 - 1997113012

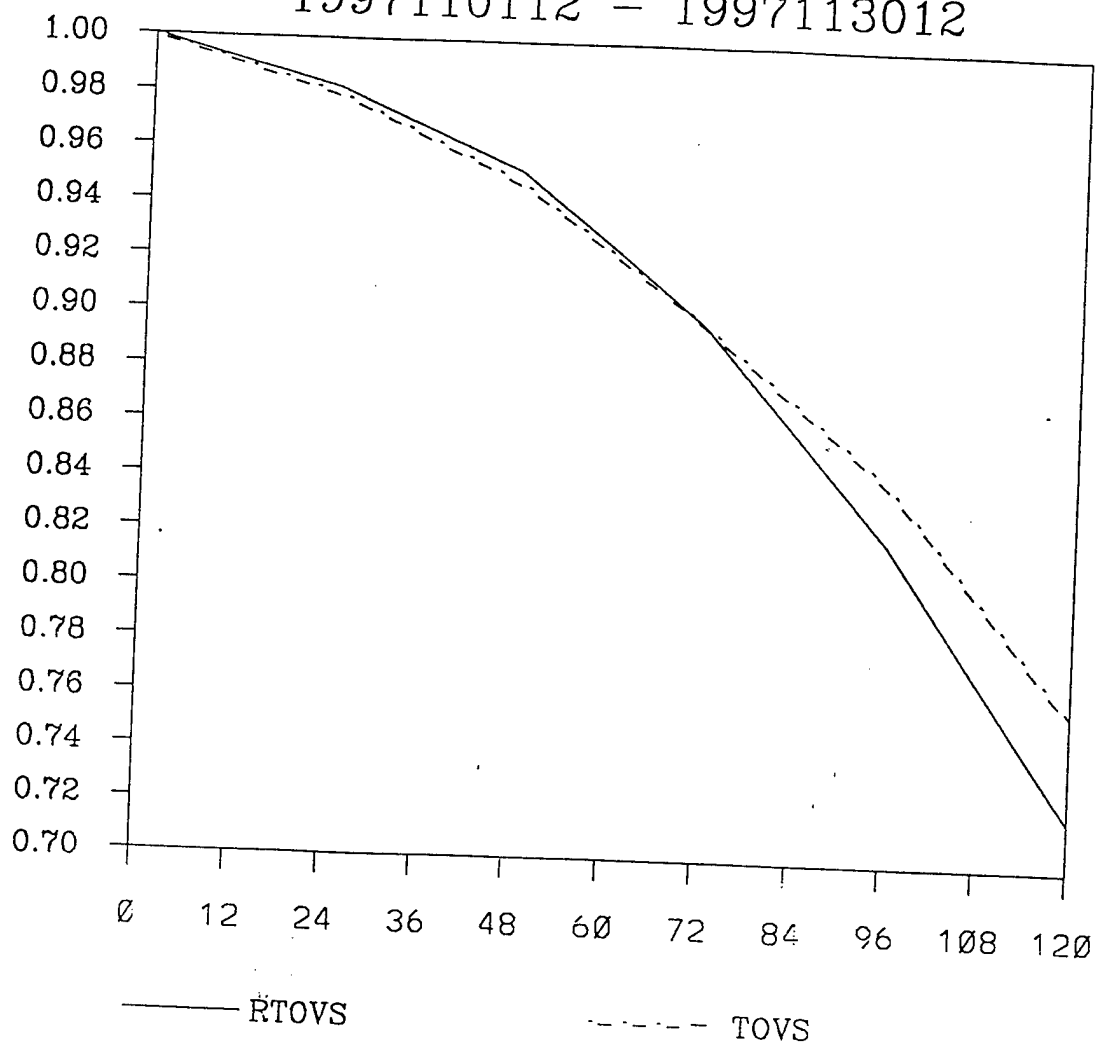


Figure 3: A comparison of the average 500 mb height anomaly correlation over the Eastern Pacific Ocean for the month of November 1997 using the retrievals from the older TOVS algorithm and from the new RTOVS algorithm in the T79L18 version of NOGAPS.

T79L18 DATA ASSIMILATION TEST
500 MB NORTH HEM RMS HEIGHT ERROR
1997110112 - 1997113012

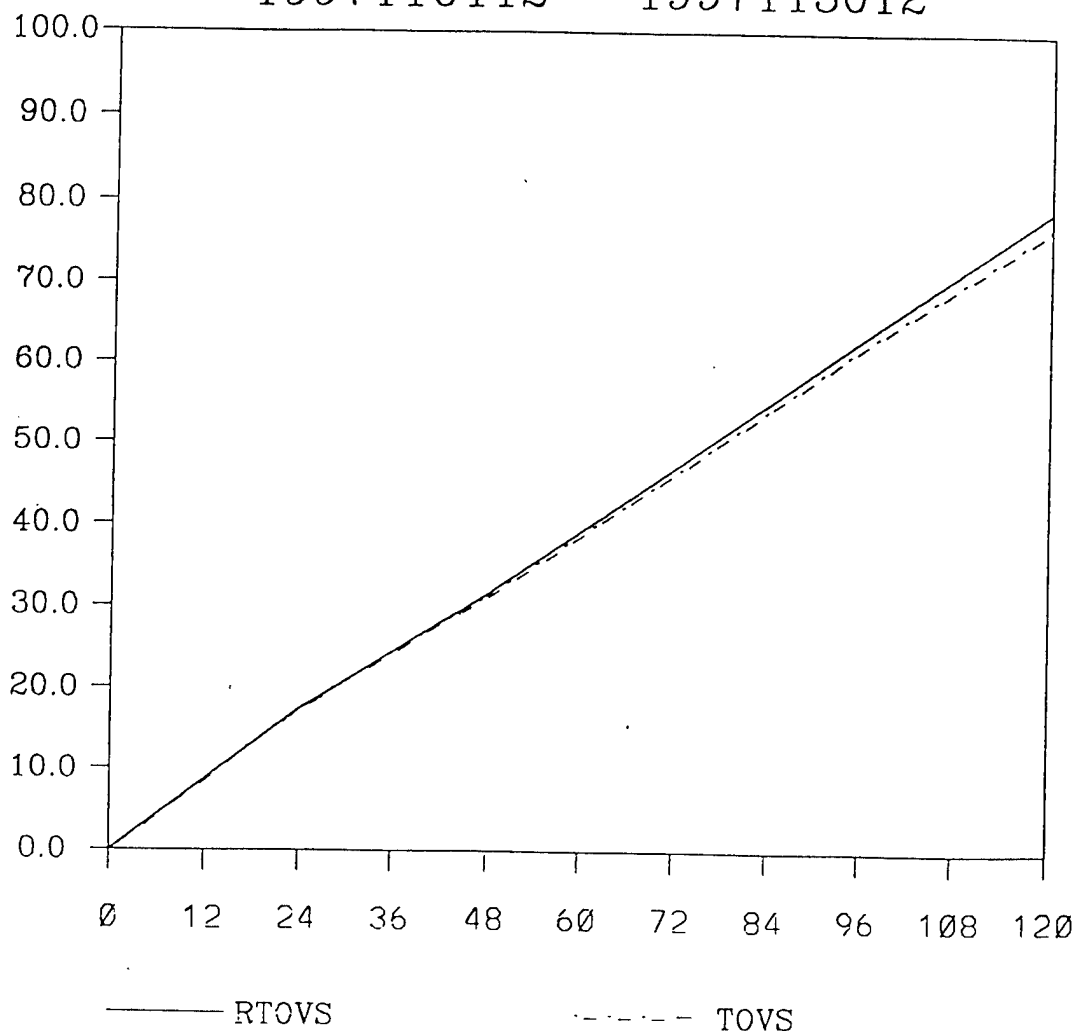


Figure 4: A comparison of the average Northern Hemisphere's 500 mb height root mean square error for the month of November 1997 using the retrievals from the older TOVS algorithm and from the new RTOVS algorithm in the T79L18 version of NOGAPS. The x axis is forecast hours (0-120 hours) and the y axis is root mean square error in meters.

T79L18 DATA ASSIMILATION TEST
500 MB ATLANTIC RMS HEIGHT ERROR
1997110112 - 1997113012

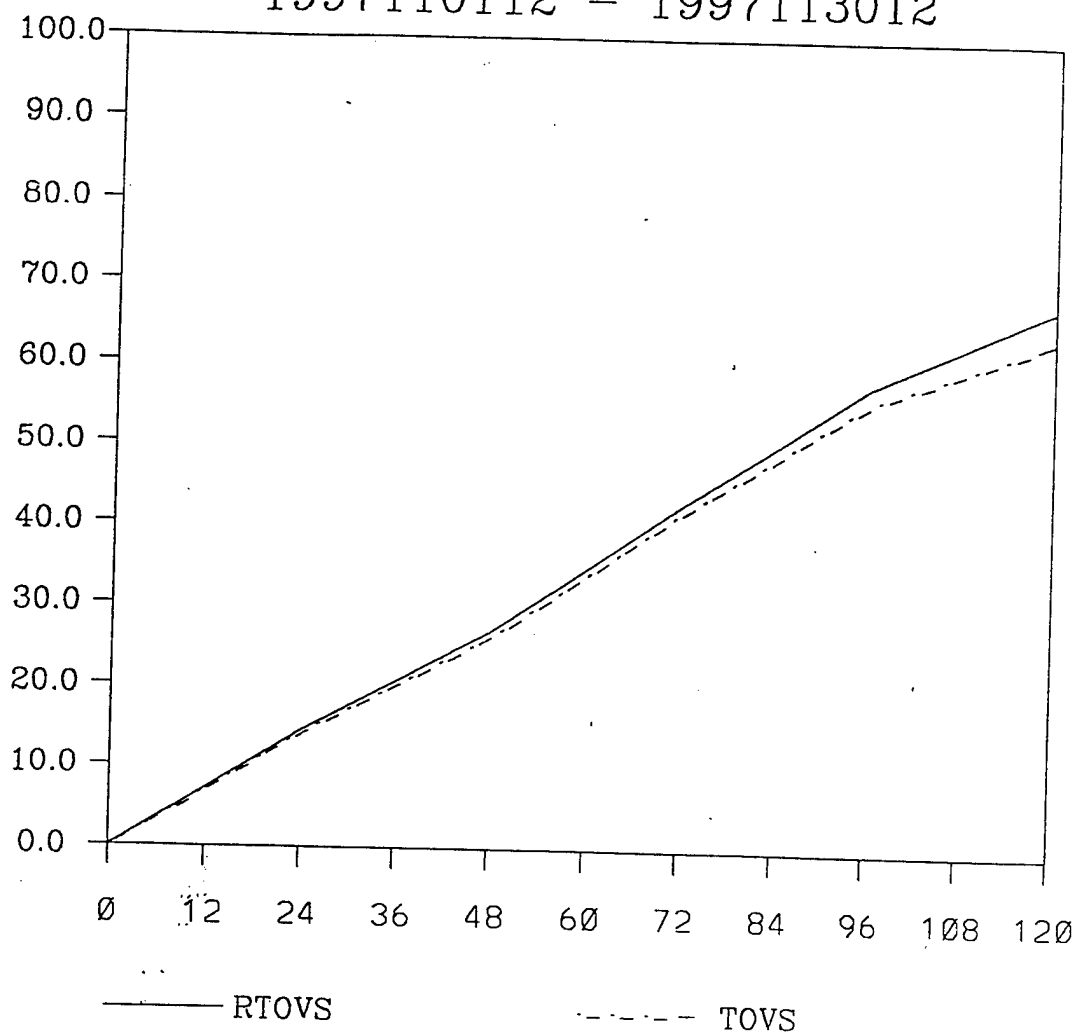


Figure 5: A comparison of the average 500 mb height root mean square error over the Atlantic Ocean for the month of November 1997 using the retrievals from the older TOVS algorithm and from the new RTOVS algorithm in the T79L18 version of NOGAPS.

T79L18 DATA ASSIMILATION TEST
500 MB EAST PAC RMS HEIGHT ERROR
1997110112 - 1997113012

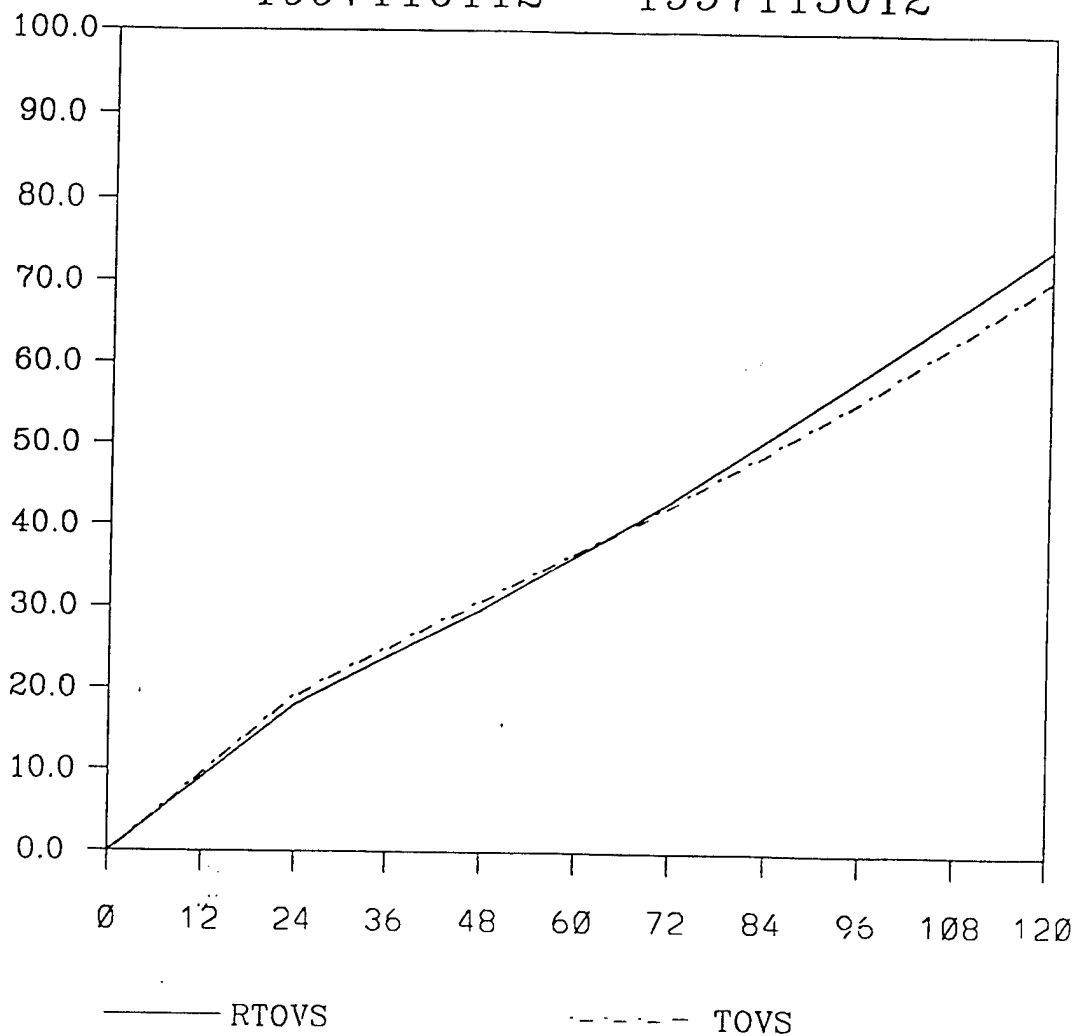


Figure 6: A comparison of the average 500 mb height mean square error over the Eastern Pacific Ocean for the month of November 1997 using the retrievals from the older TOVS algorithm and from the new RTOVS algorithm in the T79L18 version of NOGAPS.

T79L18 DATA RAOB COMPARISON
500 MB N AMERICA RMS HEIGHT ERROR
1997110112 - 1997113012

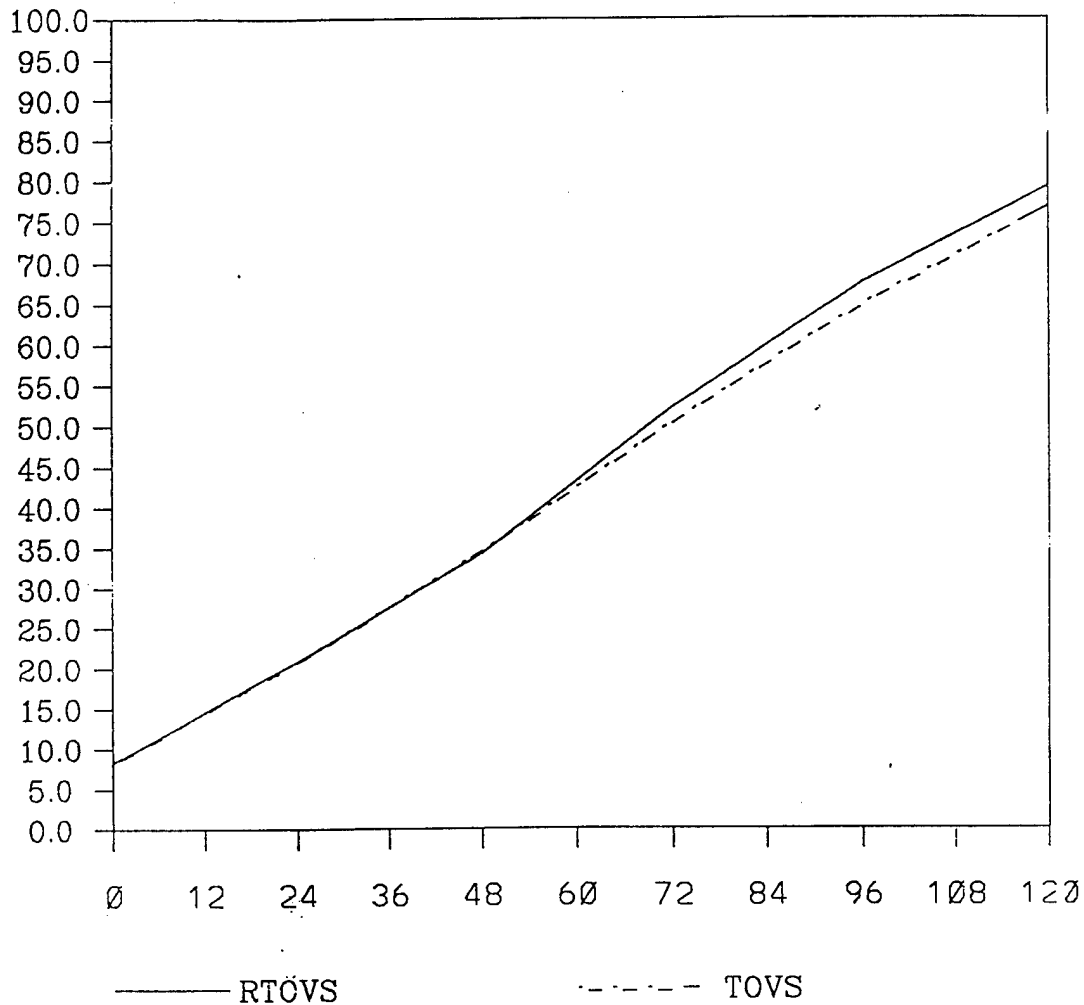


Figure 7: Graph of the 500 mb root mean square error heights using radiosondes (forecast minus radiosonde) over North America for the month of November 1997 using the T79L18 version of NOGAPS.

T79L18 DATA ASSIMILATION TEST
500 MB NORTH HEM HEIGHT ANOMALY COR
1997110112 - 1997113012

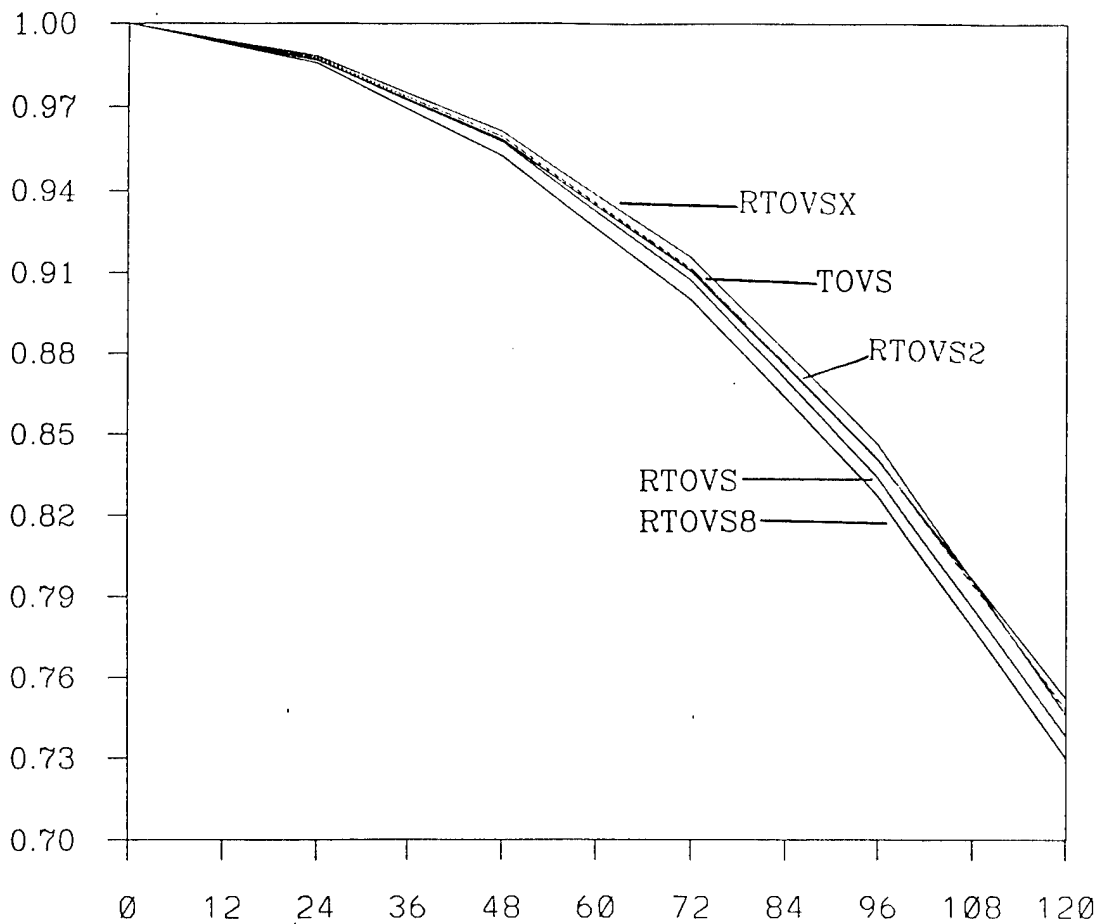
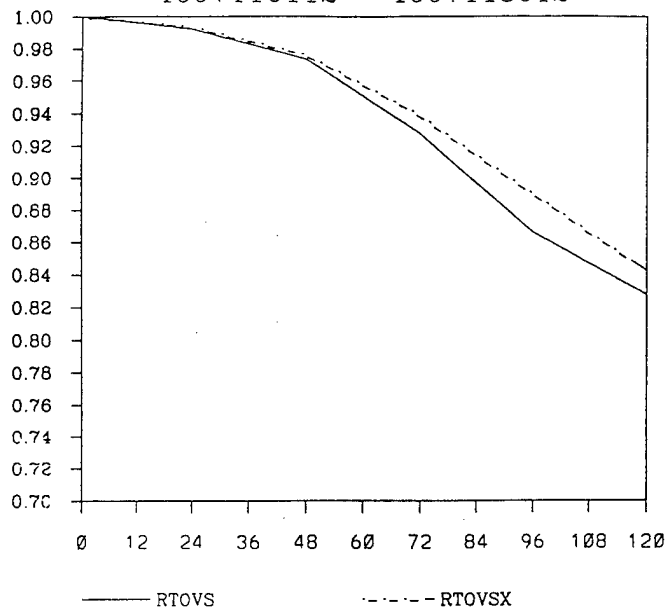
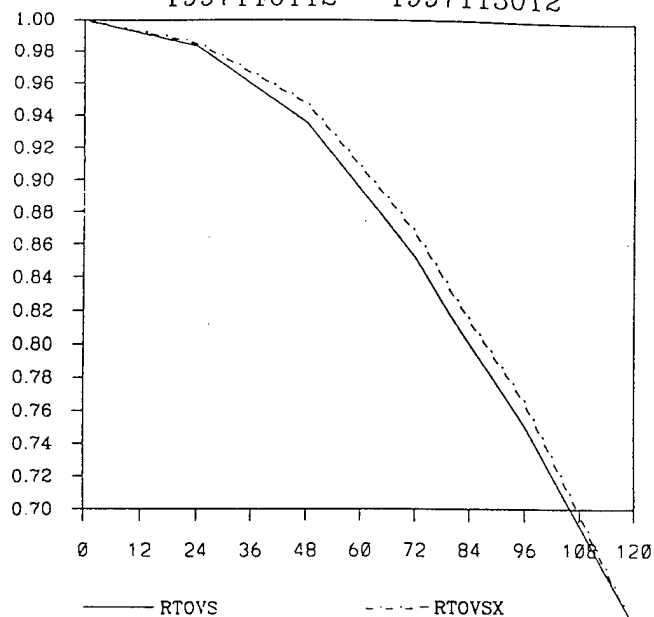


Figure 8: A comparison of the average Northern Hemisphere's 500 mb height anomaly correlation for the month of November 1997 using TOVS, the new RTOVS retrievals, and 3 different satellite errors for the RTOVS data, RTOVS2, RTOVS8, and RTOVSX (see the text for details). All test were conducted with the T79L18 version of NOGAPS.

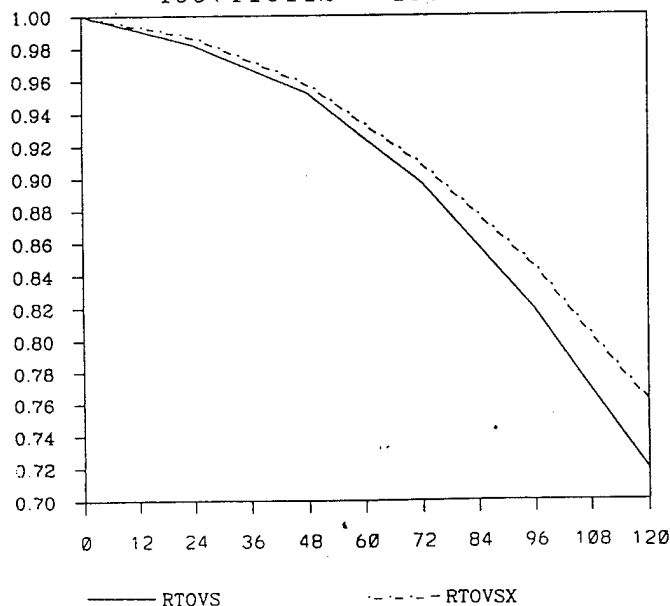
T79L18 DATA ASSIMILATION TEST
500 MB ATLANTIC HEIGHT ANOMALY COR
1997110112 - 1997113012



T79L18 DATA ASSIMILATION TEST
500 MB N AMERICA HEIGHT ANOMALY COR
1997110112 - 1997113012



T79L18 DATA ASSIMILATION TEST
500 MB EAST PAC HEIGHT ANOMALY COR
1997110112 - 1997113012



T79L18 DATA ASSIMILATION TEST
500 MB EURASIA HEIGHT ANOMALY COR
1997110112 - 1997113012

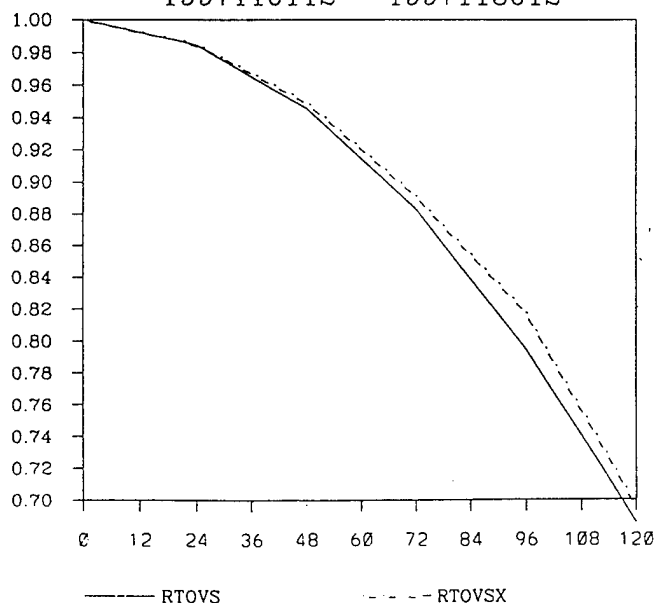
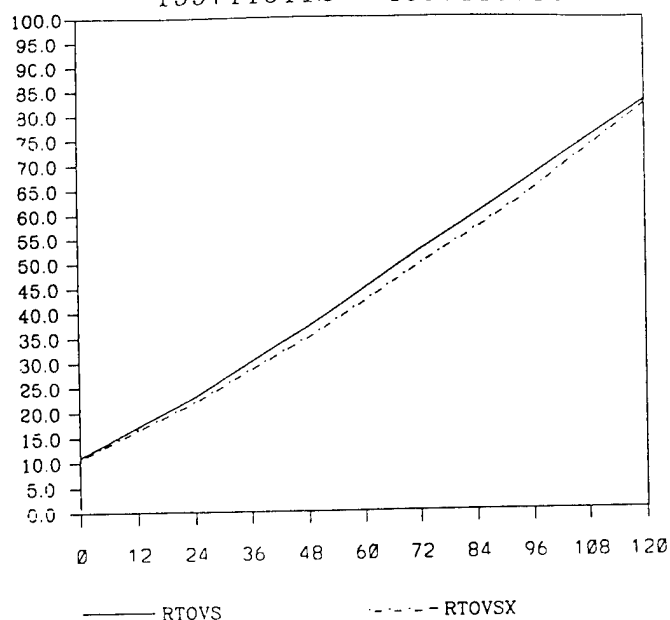
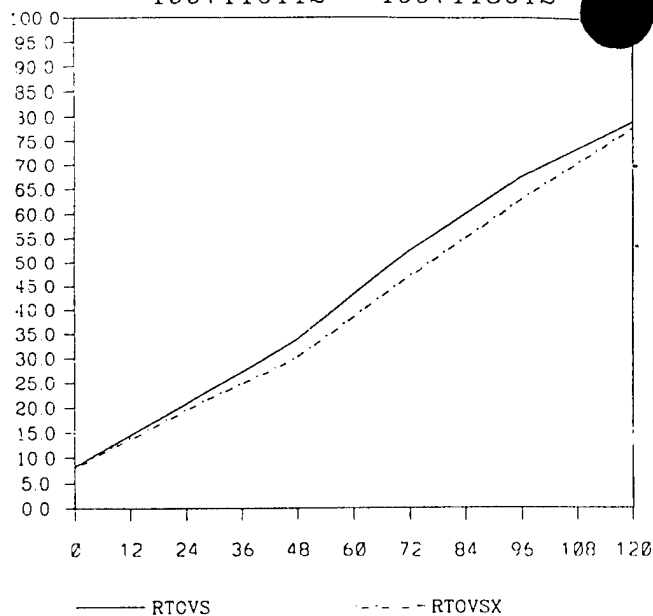


Figure 9: A comparison of the average 500 mb height anomaly correlation over the Atlantic Ocean (top left), North America (top right), Eastern Pacific (bottom left), and Europe and Asia (bottom right) for the month of November 1997 using all the new satellite retrieval data (RTOVS) and restricting the satellite retrievals in the Northern Hemisphere (RTOVSX).

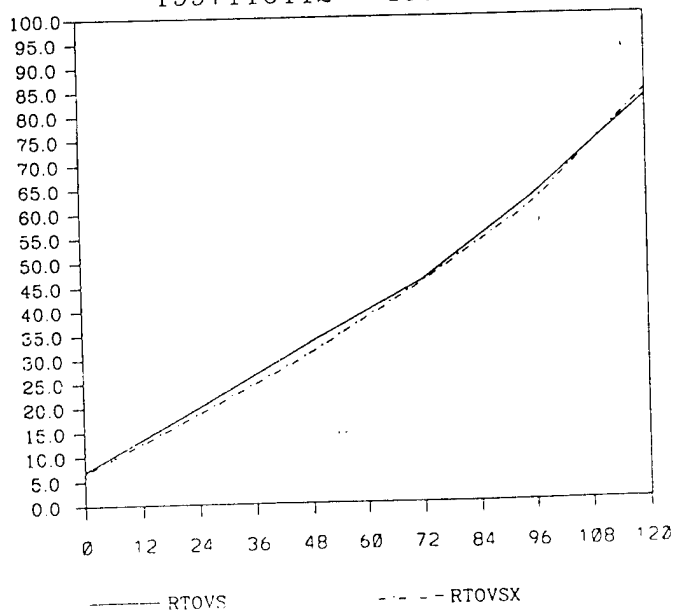
T79L18 DATA RAOB COMPARISON
500 MB NORTH HEM RMS HEIGHT ERROR
1997110112 - 1997113012



T79L18 DATA RAOB COMPARISON
500 MB N AMERICA RMS HEIGHT ERROR
1997110112 - 1997113012



T79L18 DATA RAOB COMPARISON
500 MB EUROPE RMS HEIGHT ERROR
1997110112 - 1997113012



T79L18 DATA RAOB COMPARISON
500 MB ASIA RMS HEIGHT ERROR
1997110112 - 1997113012

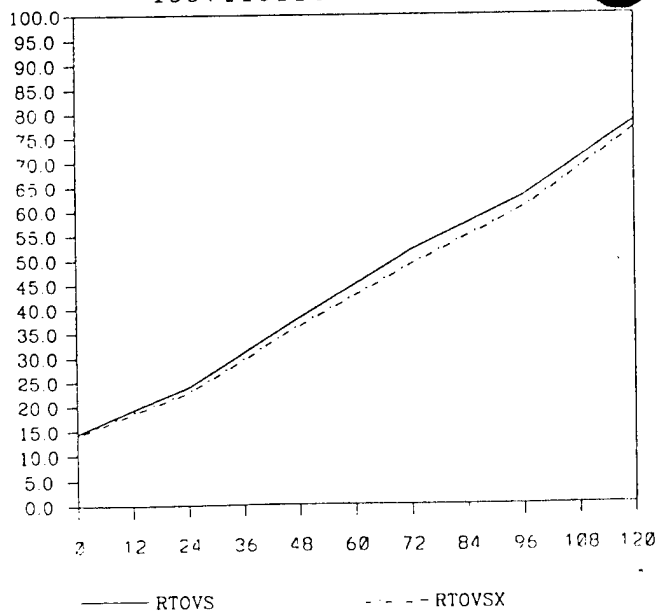
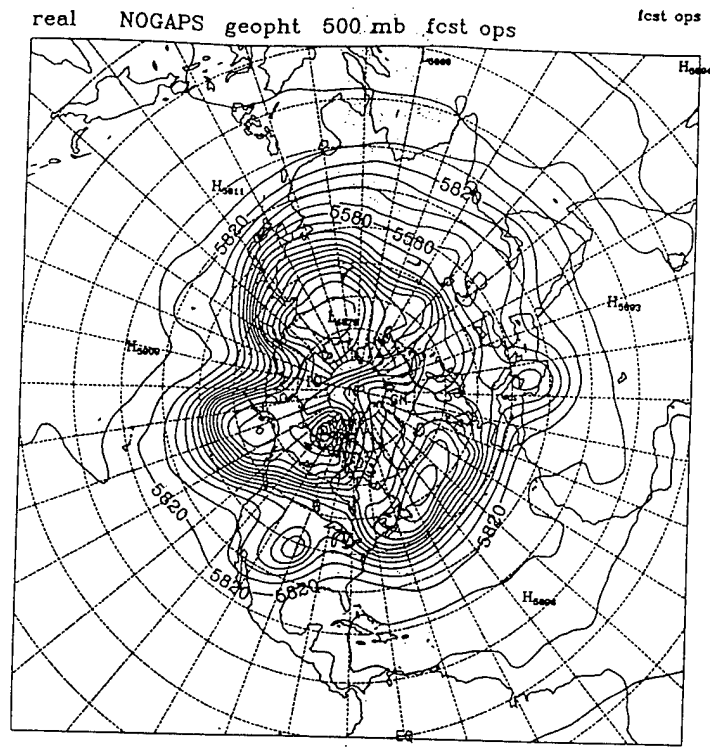
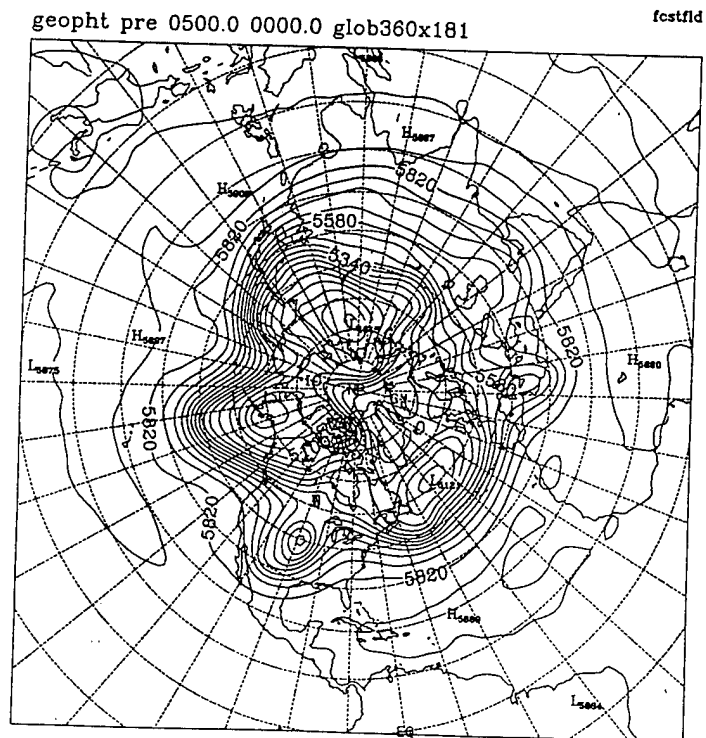


Figure 10: A comparison of the average 500 mb forecast root mean square error using radiosondes over the entire Northern Hemisphere (top left), North America (top right), Europe (bottom left), and Asia (bottom right) for the month of November 1997 using all the new satellite retrieval data (RTOVS) and restricting the satellite retrievals in the Northern Hemisphere (RTOVSX).



120 HR FORECAST VALID AT 97112800 FROM 97112300



120 HR FORECAST VALID AT 97112800 FROM 97112300

Figure 11: The top is the operational (T159L18) 120 hour 500 mb height forecast starting at 1997112300 and verifying at 1997112800, and the bottom is a plot of the T79L18 RTOVSX 120 hour forecast for the same period.